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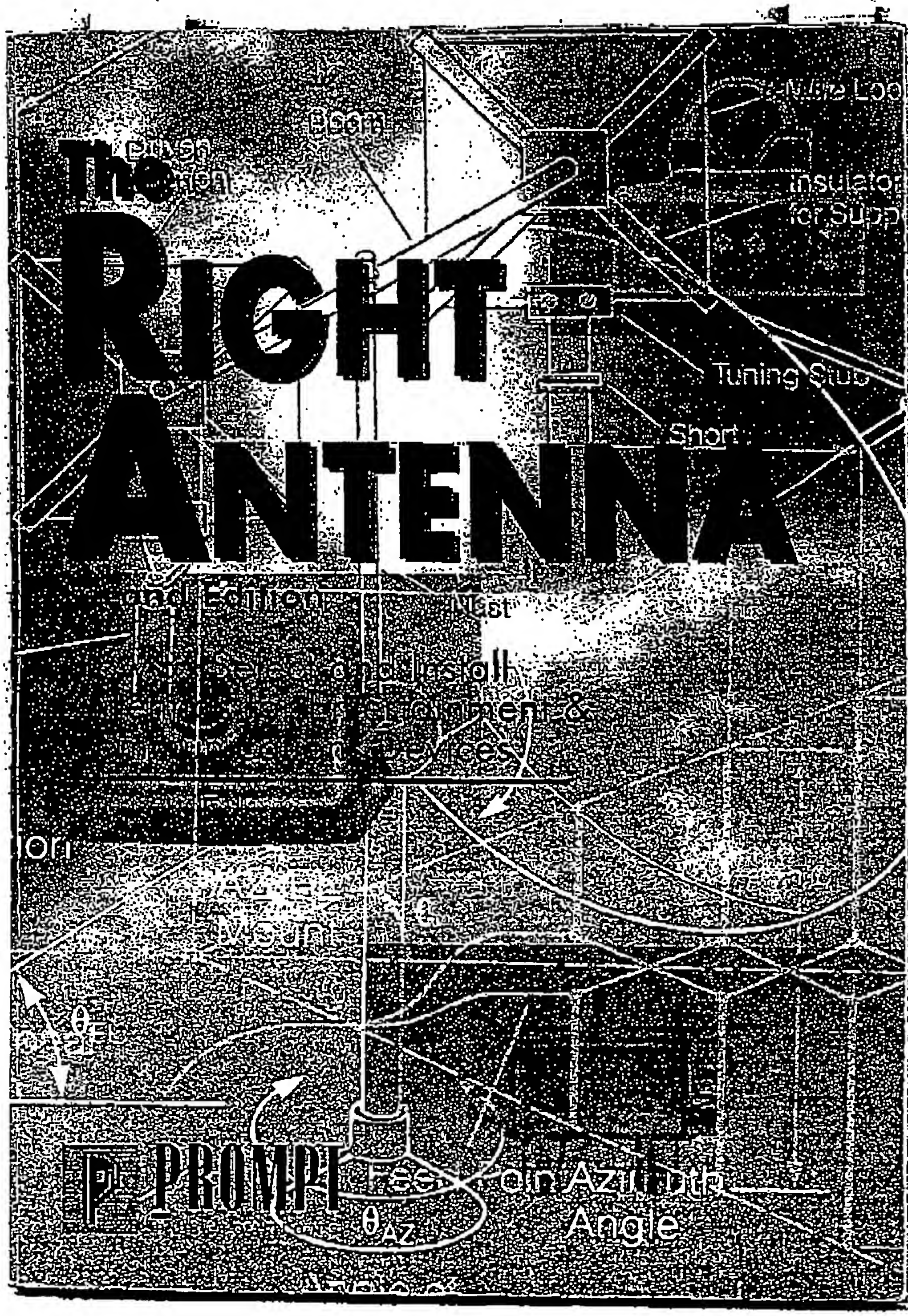
EXHIBIT

The Right Antenna (Second Edition)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Preface

In this age of information, each of us is affected by the advances in electronic communications such as AM/FM radio, television and cellular telephones. In these various modes of communications, the information travels from the transmitter to the receiver through space by electromagnetic waves. Antennas are required at both ends for the purpose of coupling the transmitter and the receiver to the space link between them. *Antennas* is intended to provide easy-to-understand information on a wide variety of antennas. Early explanation of the basic concepts of how any antenna works helps the reader understand the later explanations of the specialized types of antennas. With this understanding, readers will be better prepared to select the best antenna for their needs. In addition, readers can build their own antennas as described in Chapter 11.

Antennas begins by explaining how antennas work in general and then isolates antennas for TV and FM. A separate chapter is devoted to DSS satellite TV antennas, TV and FM noise and interference, CB and cellular antennas, and antennas used by "hams" for amateur band operation. The basic concepts of cellular telephone system operation are explained and the most popular antennas are discussed. The chapter on the fast-growing area of DSS satellite TV provides enough information for readers to intelligently select their own satellite system.

The antenna problems encountered in fringe areas, high-noise areas, and with various types of interference are discussed, and practical solutions offered. In order for any antenna to be effective, it must be the right type for the job, and be safely and properly installed. For that reason, the book has a chapter on antenna installation. A safety checklist is included.

The book concludes with a chapter on specific antenna projects that can be constructed easily, and a chapter on new trends in TV antennas, some of which attach to DSS dish antennas for reception of local stations. The antenna projects should be of interest to shortwave, scanner, amateur, mobile and business radio users. Construction details and parts lists are included.

Antennas is rather broad in its scope of coverage, though we have attempted to include sufficient depth of coverage to provide a handy reference to the student, technician, or consumer. After reading this book you should be able to select an antenna, even build it, place it correctly, and install it properly to obtain maximum performance whether in a strong signal area or in a fringe area. We hope we have met this goal.

AJE, KEB, MP

Wavelength

The full range of the different radio frequencies is called a spectrum. It extends from the 10 kilohertz (10,000 cycles per second) to 300 gigahertz (300 billion cycles per second). It is divided into bands of frequencies, as shown in *Table 1-1*. The table also shows how the waves are classified by wavelength. Wavelength (λ) is defined as the distance the wave travels in the time required to complete one cycle. Since, as was stated earlier, the speed is known, the wavelength can be found by the relationship:

$$\text{wavelength } (\lambda \text{ in meters}) = \frac{\text{velocity } (V_1, \text{ meters per sec})}{\text{frequency } (F_1, \text{ cycles per sec})}$$

Note that the higher the frequency, the shorter the wavelength.

Antennas usually are designed to have a length equivalent to one-half, one-quarter or some other sub-multiple (or multiple) of a wavelength. The amount of voltage induced in the receiving antenna depends primarily upon the intensity of the radiated wave, which, in turn, depends mainly upon the transmitting antenna characteristics, and the power at the transmitting antenna.

Table 1-1 The Radio Frequency Spectrum

Frequency (In megahertz)	Name of Band	Abbrev	Wavelength (In meters)
0.01 - 0.03	Very low frequency	VLF	300,000 - 10,000
0.03 - 0.3	Low frequency	LF	10,000 - 1,000
0.3 - 3.0	Medium frequency	MF	1,000 - 100
3.0 - 30	High frequency	HF	100 - 10
30 - 300	Very high frequency	VHF	10 - 1
300 - 3,000	Ultra high frequency	UHF	1 - 0.1
3,000 - 30,000	Super high frequency	SHF	0.1 - 0.01
30,000 - 300,000	Extremely high frequency	EHF	0.01 - 0.001

Polarization of a Radio Wave

Figure 1-4 shows the changing electric and magnetic fields produced in an antenna. The term polarization, as applied to antennas, defines the direction of the electric E and magnetic H fields, respectively. The direction of the E field determines an antenna's polarization. An antenna erected so that the radiating element is vertical produces vertical electric waves and, therefore, the antenna is said to be vertically polarized; correspondingly for horizontally polarized antennas. A pure vertical polarized wave will not produce a signal in a horizontally polarized antenna.

Horizontal polarization is standard in the United States for both FM and TV antennas. It was chosen originally because most types of man-made noise are vertically polarized. Thus, horizontal polarization helps reduce Interference from such sources.

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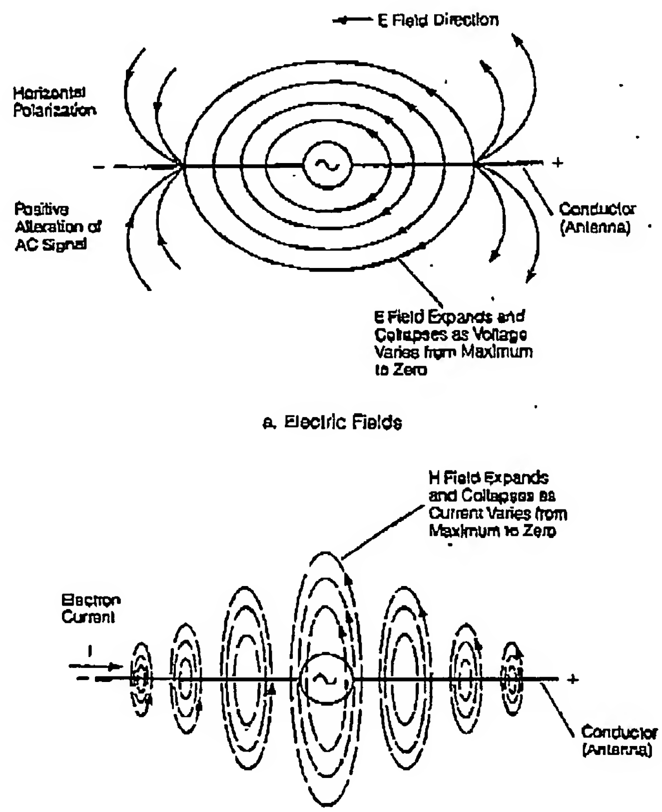
Figure 1-4. Magnetic and Electric Fields Around a Current Carrying Conductor



b. Magnetic Fields

Circular Polarization

Because of the increasing popularity of FM portable radios with vertical whip antennas, the FCC has authorized a combination of vertical and horizontal polarization known as circular polarization. In a circularly polarized wave, the E and H fields rotate as they travel through space, making one complete revolution in one wave length (like a corkscrew). Such a wave is received equally well by either a vertically polarized or horizontally polarized antenna.

Recently the FCC has authorized the same combination for TV broadcasting. This results in some improvement in reception by portable television receivers with built-in antennas. Also, a special receiving antenna can be used that is sensitive to the direction of rotation of a circularly polarized wave. This reduces "ghosts" due to reflections because the direction of rotation of circular polarization is reversed when the signal is reflected.

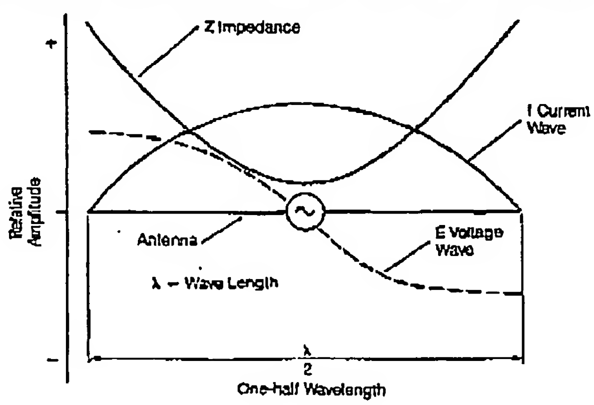
Antenna Impedance

An antenna's impedance, as shown in the following equation, is defined as the ratio of voltage to current at the measuring point:

$$\text{Impedance} = \frac{\text{voltage}}{\text{current}}$$

When the impedance is a minimum, the antenna is said to be resonant at the applied frequency. Under these conditions, for the particular resonant frequency and for a given power, the current in a transmitting antenna is greatest. The impedance of any antenna varies from point to point along its length. This can be seen in *Figure 1-5* which illustrates a plot of current, voltage and impedance along a resonant antenna. The lowest impedance occurs where the current is maximum (at the center).

Figure 1-5. Voltage, Current and Impedance Distribution in an Antenna



Gain and Directivity

When an electromagnetic wave radiates equally in all directions from a point source in free space, a spherical wavefront results. This is shown in *Figure 1-6a*. Such a source is termed an isotropic source. If a plane is cut through the sphere, as shown in *Figure 1-6b*, the radiation pattern is circular or omnidirectional. An antenna is bidirectional (*Figure 1-6c*) if it concentrates energy in two directions, or unidirectional if it concentrates energy in one direction. An antenna is said to

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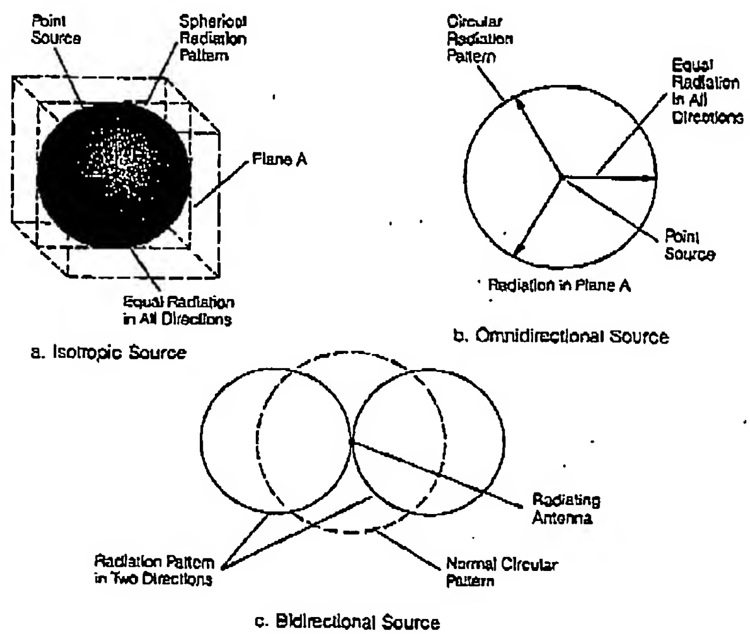
Figure 1-6. Radiation Sources



have gain if the energy radiated in a particular direction is greater than the energy that would be radiated from an isotropic antenna in the same direction. The gain results because of the concentration of energy in the particular direction. Antenna gain is very different from amplifier gain. Power amplifiers output more power than provided to their input. Feeding a power of 100 watts to an antenna does not result in more than 100 watts of radiated energy. Antenna gain is the strength of the radiated field in a particular direction relative to a reference antenna, usually the isotropic source.

Antenna Patterns and Coverage

A radiation pattern is a graph of radiated field strength versus angle or direction from the antenna. The radiation pattern for a horizontal half-wave Hertz antenna is shown in *Figure 1-7*. For this antenna, the pattern shows that maximum field strength occurs at right angles to the antenna while virtually no energy is propagated from the ends. As shown in *Figure 1-7*, the antenna's beamwidth is the angular separation between the half-power points on the radiation pattern.

Another factor that affects the coverage of an antenna is its effective height. This is the height of the antenna's center of radiation above average terrain.